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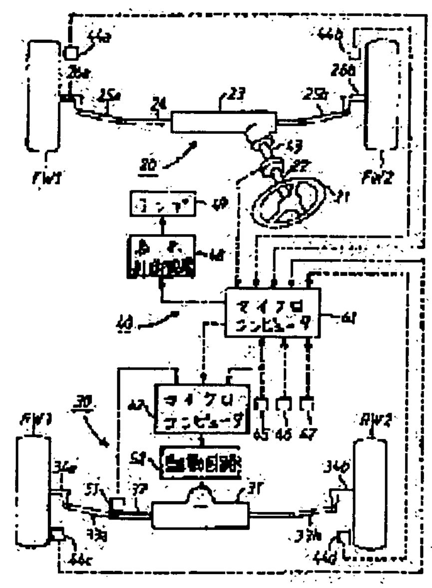
(54) SLIP STATE EVALUATING DEVICE FOR VEHICLE

(57)Abstract:

PURPOSE: To correctly evaluate the slip state of a vehicle.

CONSTITUTION: The first evaluation value indicating the longitudinal slip quantity of wheels is calculated based on the rotating speed difference of the wheels detected by wheel speed sensors 44a-44d. The reference lateral acceleration of a vehicle is calculated based on the vehicle speed calculated based on rotating speeds of the wheels and the yaw rate detected by a yaw rate sensor 45, and the second evaluation value indicating the lateral slip quantity of the wheels is calculated based on the difference between the reference lateral acceleration and the lateral acceleration detected by a lateral acceleration sensor 47. The reference yaw rate of the vehicle is calculated based on the calculated vehicle speed and the steering angle detected by a front wheel steering angle sensor 43, and the third evaluation value indicating the slip quantity of the wheels around the vertical axis is calculated in response to the difference between the reference yaw rate and the detected yaw rate. The maximum value of the first through third evaluation values is extracted as the value indicating the final slip state of the wheels.



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CLAIMS

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(57) [Claim(s)]
[Claim 1] Equipment by which the slip condition of a wheel characterized by providing the following is evaluated A wheel speed detection means to detect each rotational speed of two or more wheels, respectively A vehicle speed detection means to detect the vehicle speed A lateral acceleration detection means to detect the lateral acceleration of a car A yaw rate detection means to detect the yaw rate of a car, and a 1st evaluation value count means to calculate the 1st evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of a cross direction to the difference of **** rotational speed based on said each detected rotational speed, A criteria lateral acceleration count means to calculate ideal lateral acceleration as criteria lateral acceleration for a revolution car based on said detected vehicle speed and said detected yaw rate, A 2nd evaluation value count means to calculate the 2nd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the longitudinal direction of a wheel to the difference of **** lateral acceleration based on the difference of said detected lateral acceleration and said calculated criteria lateral acceleration, A slip condition evaluation value derivation means to derive the maximum of said calculated 1st and 2nd evaluation values as an evaluation value of the slip condition of a wheel
[Claim 2] Equipment by which the slip condition of a wheel characterized by providing the following is evaluated A wheel speed detection means to detect each rotational speed of two or more wheels, respectively A vehicle speed detection means to detect the vehicle speed A steering angle detection means to detect the steering angle of a front wheel A yaw rate detection means to detect the yaw rate of a car, and a 1st evaluation value count means to calculate the 1st evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of a cross direction to the difference of **** rotational speed based on said each detected rotational speed, A criteria yaw rate count means to calculate an ideal yaw rate as a criteria yaw rate for a revolution car based on said detected vehicle speed and said detected steering angle, A 2nd evaluation value count means to calculate the 2nd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of the circumference of vertical axes to the difference of a **** yaw rate based on the difference of said detected yaw rate and said calculated criteria yaw rate, A slip condition evaluation value derivation means to derive the maximum of said calculated 1st and 2nd evaluation values as an evaluation value of the slip condition of a wheel

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the slip condition evaluation equipment of the wheel which can be used for the various control units of the car which controls the warning device which tells an operator about the slip condition of a wheel or the steering property of a car, a drive property, etc. by starting the slip condition evaluation equipment of a wheel by which the slip condition of a wheel is evaluated, especially evaluating said slip condition, and enabling it to output.
[0002]
[Description of the Prior Art] While detecting from the former that the wheel has slipped, enabling it to run by answering this detection, controlling the brake oil pressure given to a wheel at the time of car braking, restricting the acceleration at the time of car revolution, or controlling the steer property of a car, and stabilizing a car is known well. And if in charge of detection of the slip condition of a wheel in this case, he is trying to detect the slip (slipping) of a wheel based on the rotational speed of a wheel. (For example, refer to JP,62-146762,A)
[0003]
[Problem(s) to be Solved by the Invention] However, even if lateral slipping arose for the wheel or slipping of the circumference of vertical axes arose for the wheel since the slip condition of a wheel was detected based on the rotational speed of a wheel, i.e., slipping of a cross direction, if it was in the above-mentioned conventional equipment, these slipping could not be detected exactly and the slip condition of a wheel was not able to be evaluated correctly. It was made in order that this invention might cope with the above-mentioned problem, and the purpose is in offering the slip condition evaluation equipment of a wheel by which the slip condition of a wheel is evaluated correctly.
[0004]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, the description on the 1st [of this invention] configuration A wheel speed detection means to detect each rotational speed of two or more wheels, respectively (it corresponds to the wheel speed sensors 44a-44d of an example), A vehicle speed detection means to detect the vehicle speed (it corresponds to processing of the wheel speed sensors 44a-44d of an example, the yaw rate sensor 45, the order acceleration sensor 46, and steps 106-112), A lateral acceleration detection means to detect the lateral acceleration of a car (it corresponds to the lateral acceleration sensor 47 of an example), A yaw rate detection means to detect the yaw rate of a car (it corresponds to the yaw rate sensor 45 of an example), A 1st evaluation value count means to calculate the 1st evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of a cross direction to the difference of **** rotational speed based on said each detected rotational speed (it corresponds to processing of step 114,116 of an example), A criteria lateral acceleration count means to calculate ideal lateral acceleration as criteria lateral acceleration for a revolution car based on said detected vehicle speed and said detected yaw rate (it corresponds to processing of step 118 of an

example), A 2nd evaluation value count means to calculate the 2nd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the longitudinal direction of a wheel to the difference of **** lateral acceleration based on the difference of said detected lateral acceleration and said calculated criteria lateral acceleration (it corresponds to processing of step 120,122 of an example), It is in having had a slip condition evaluation value derivation means (it corresponding to processing of step 132 of an example) to derive the maximum of said calculated 1st and 2nd evaluation values as an evaluation value of the slip condition of a wheel. Moreover, a wheel speed detection means by which the description on the 2nd [of this invention] configuration detects each rotational speed of two or more wheels, respectively (it corresponds to the wheel speed sensors 44a-44d of an example), A vehicle speed detection means to detect the vehicle speed (it corresponds to processing of the wheel speed sensors 44a-44d of an example, the yaw rate sensor 45, the order acceleration sensor 46, and steps 106-112), A steering angle detection means to detect the steering angle of a front wheel (it corresponds to the front-wheel steering angle sensor 43 of an example), A yaw rate detection means to detect the yaw rate of a car (it corresponds to the yaw rate sensor 45 of an example), A 1st evaluation value count means to calculate the 1st evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of a cross direction to the difference of **** rotational speed based on said each detected rotational speed (it corresponds to processing of step 114,116 of an example), A criteria yaw rate count means to calculate an ideal yaw rate as a criteria yaw rate for a revolution car based on said detected vehicle speed and said detected steering angle (it corresponds to processing of step 124,126 of an example), A 2nd evaluation value count means to calculate the 2nd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of the circumference of vertical axes to the difference of a **** yaw rate based on the difference of said detected yaw rate and said calculated criteria yaw rate (it corresponds to processing of step 128,130 of an example), It is in having had a slip condition evaluation value derivation means (it corresponding to processing of step 132 of an example) to derive the maximum of said calculated 1st and 2nd evaluation values as an evaluation value of the slip condition of a wheel. Moreover, a wheel speed detection means by which the description on the 3rd [of this invention] configuration detects each rotational speed of two or more wheels, respectively (it corresponds to the wheel speed sensors 44a-44d of an example), A vehicle speed detection means to detect the vehicle speed (it corresponds to processing of the wheel speed sensors 44a-44d of an example, the yaw rate sensor 45, the order acceleration sensor 46, and steps 106-112), A steering angle detection means to detect the steering angle of a front wheel (it corresponds to the front-wheel steering angle sensor 43 of an example), A lateral acceleration detection means to detect the lateral acceleration of a car (it corresponds to the lateral acceleration sensor 47 of an example), A yaw rate detection means to detect the yaw rate of a car (it corresponds to the yaw rate sensor 45 of an example), A 1st evaluation value count means to calculate the 1st evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of a cross direction to the difference of **** rotational speed based on said each detected rotational speed (it corresponds to processing of step 114,116 of an example), A criteria lateral acceleration count means to calculate ideal lateral acceleration as criteria lateral acceleration for a revolution car based on said detected vehicle speed and said detected yaw rate (it corresponds to processing of step 118 of an example), A 2nd evaluation value count means to calculate the 2nd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the longitudinal direction of a wheel to the difference of **** lateral acceleration based on the difference of said detected lateral acceleration and said calculated criteria lateral acceleration (it corresponds to processing of step 120,122 of an example), A criteria yaw rate count means to calculate an ideal yaw rate as a criteria yaw rate for a revolution car based on said detected vehicle speed and said detected steering angle (it corresponds to processing of step 124,126 of an example), A 3rd evaluation value count means to calculate the 3rd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of the circumference of vertical axes to the difference of a **** yaw rate based on the

difference of said detected yaw rate and said calculated criteria yaw rate (it corresponds to processing of step 128,130 of an example), It is in having had a slip condition evaluation value derivation means (it corresponding to processing of step 132 of an example) to derive the maximum of said the 1st calculated thru/or 3rd evaluation values as an evaluation value of the slip condition of a wheel. [0005]

[Function] In the 1st description of this invention constituted as mentioned above If slipping arises between a wheel and a road surface in the travelling direction (cross direction) of a wheel at the time of the acceleration and deceleration of a car etc. The difference corresponding to said slippage arises between each rotational speed of two or more wheels, and the slippage of the wheel of this cross direction is calculated by the difference of each of said rotational speed as the 1st evaluation value which carried out proportionally [abbreviation] based on each rotational speed of the wheel detected by the wheel speed detection means with the 1st evaluation value count means. Moreover, if the car is circling in the ideal condition (condition that the slippage of a lateral wheel is small), for a car, ideal lateral acceleration will become settled at the vehicle speed and a yaw rate, and this lateral acceleration will be calculated as criteria lateral acceleration with a criteria lateral acceleration count means based on the yaw rate detected by the vehicle speed and the yaw rate detection means which were detected by the vehicle speed detection means. On the other hand, when lateral slipping arises between a wheel and a road surface during car revolution, it is what the difference corresponding to said slippage produces between the actual lateral acceleration of a car, and said criteria lateral acceleration. The slippage of the wheel of this longitudinal direction is calculated by the difference of **** lateral acceleration with the 2nd evaluation value count means as the 2nd evaluation value which carried out proportionally [abbreviation] based on the difference of the lateral acceleration detected by the lateral acceleration detection means, and said calculated criteria lateral acceleration. And the maximum of said calculated 1st and 2nd evaluation values is drawn as an evaluation value of a slip condition by the slip condition evaluation value derivation means. Moreover, in the 2nd description of this invention constituted as mentioned above, although it is the same about count of the 1st evaluation value, count of the 2nd evaluation value in the description on said 1st configuration differs. That is, if the car is circling in the ideal condition (condition that the slippage of a lateral wheel is small), for a car, an ideal yaw rate will become settled on the vehicle speed and the steering square of a front wheel, and this yaw rate will be calculated as a criteria yaw rate with a criteria yaw rate count means based on the steering angle of the front wheel detected by the vehicle speed and the steering angle detection means which were detected by the vehicle speed detection means. On the other hand, if slipping of the circumference of vertical axes arises between a wheel and a road surface during car revolution It is what the difference corresponding to said slippage produces between the actual yaw rate of a car, and said criteria yaw rate. The slippage of the wheel of the circumference of these vertical axes is calculated by the difference of a **** yaw rate with the 2nd evaluation value count means as the 2nd evaluation value which carried out proportionally [abbreviation] based on the yaw rate detected by the yaw rate detection means, and said calculated criteria yaw rate. And also in this 2nd description, the maximum of said calculated 1st and 2nd evaluation values is drawn as an evaluation value of a slip condition by the slip condition evaluation value derivation means. Furthermore, it sets with the 3rd description of this invention constituted as mentioned above. While the 1st and 2nd evaluation value is calculated by carrying out like said 1st description, the 2nd evaluation value of said 2nd description is calculated as the 3rd evaluation value, and the maximum of said the 1st calculated thru/or 3rd evaluation values is drawn as an evaluation value of a slip condition by the slip condition evaluation value derivation means.

[0006]

[Effect of the Invention] Like the above-mentioned operation explanation, while the slippage of the wheel of a cross direction is calculated as the 1st evaluation value according to the description on the 1st [of this invention] configuration, the slippage of a lateral wheel is calculated as the 2nd evaluation value, and the maximum of these 1st and 2nd evaluation values is drawn as a final evaluation value of the slip condition

of a wheel. Therefore, according to the description on the 1st [of this this invention] configuration, the evaluation value as which not only slipping of the cross direction on the road surface of a wheel but slipping over a longitudinal direction was considered will be calculated, and the slip condition of a wheel can evaluate now correctly and easily using a numeric value. Moreover, according to the description on the 2nd [of this invention] configuration, while the slippage of the wheel of a cross direction is calculated as the 1st evaluation value, the slippage of the wheel of the circumference of vertical axes is calculated as the 2nd evaluation value, and the maximum of these 1st and 2nd evaluation values is drawn as a final evaluation value of the slip condition of a wheel. Therefore, according to the description on the 2nd [of this this invention] configuration, the evaluation value as which not only slipping of the cross direction on the road surface of a wheel but slipping over the circumference of vertical axes was considered will be calculated, and the slip condition of a wheel can evaluate now correctly and easily using a numeric value. Moreover, according to the description on the 3rd [of this invention] configuration, while the slippage of the wheel of the circumference of a cross direction, a longitudinal direction, and vertical axes is calculated as the 1st - the 3rd evaluation value, the maximum of these the 1st - 3rd evaluation values is drawn as a final evaluation value of the slip condition of a wheel. Therefore, according to the description on the 3rd [of this this invention] configuration, the evaluation value as which slipping over all the directions of [on the road surface of a wheel] was considered will be calculated, and the slip condition of a wheel can evaluate now more correctly and easily using a numeric value.

[0007]

[Example] Hereafter, if one example of this invention is explained using a drawing, drawing 1 shows roughly the whole four-flower steering vehicle which applied the slip condition evaluation equipment of the wheel concerning this invention. This four-flower steering vehicle is equipped with the front-wheel power steering system 20 which steers the right-and-left front wheels FW1 and FW2, the rear wheel power steering system 30 which steers the right-and-left rear wheels RW1 and RW2, and the electrical control unit 40 which controls the rear wheel power steering system 30 electrically.

[0008] The front-wheel power steering system 20 is equipped with the steering shaft 22 which fixed the handle 21 to upper limit. The lower limit of the steering shaft 22 is connected to the rack bar 24 supported possible [the displacement to shaft orientations] in the steering gearbox 23, and this bar 24 is displaced to shaft orientations according to rotation of a handle 21. The right-and-left front wheels FW1 and FW2 are connected to the both ends of the rack bar 24 through tie rods 25a and 25b and steering knuckle arms 26a and 26b, and the right-and-left front wheels FW1 and FW2 are steered according to the variation rate of the shaft orientations of the rack bar 24.

[0009] The rear wheel power steering system 30 is equipped with the actuator 31 controlled electrically, and this actuator 31 drives the relay rod 32 prepared in shaft orientations possible [displacement] to shaft orientations. The right-and-left rear wheels RW1 and RW2 are connected to the both ends of the relay rod 32 through tie rods 33a and 33b and steering knuckle arms 34a and 34b, and the right-and-left rear wheels RW1 and RW2 are steered according to the variation rate of the shaft orientations of the relay rod 32.

[0010] The electrical control unit 40 is equipped with microcomputers 41 and 42. The microcomputer 41 has memorized the program corresponding to drawing 2 and the flow chart of 3, and evaluates the slip condition of each rings FW1, FW2, RW1, and RW2 by this program execution. Moreover, this microcomputer 41 has the table constituted by ROM, and the various multipliers and the evaluation values GB0, GB1, Tr, LX, LY, gamma0, a, b, and LZ (drawing 4 - 12 reference) which are used for this table at the time of said program execution are memorized.

[0011] The front-wheel steering angle sensor 43, the wheel speed sensors 44a-44d, the yaw rate sensor 45, the order acceleration sensor 46, and the lateral acceleration sensor 47 are connected to the input of a microcomputer 41. The front-wheel steering angle sensor 43 is attached to the steering shaft 22, detects the front-wheel steering angle theta by detecting the angle of rotation of the same axle 22, and outputs the detecting signal showing this steering angle theta. It is prepared near each rings FW1, FW2, RW1, and

RW2, the rotational speed VFL, VFR, VRL, and VRR of each rings FW1, FW2, RW1, and RW2 is detected, and the wheel speed sensors 44a-44d are these rotational speed VFL, VFR, VRL, and VRR. The detecting signal to express is outputted, respectively. It is fixed to the center-of-gravity location of a car body, and the yaw rate sensor 45 detects the yaw rate gamma by detecting the angular rate of rotation of the car body of the circumference of vertical axes, and outputs the detecting signal showing this yaw rate gamma. The order acceleration sensor 46 is also fixed to a car body, and it is the acceleration GX of the cross direction of a car. It detects and is this acceleration GX. The detecting signal to express is outputted. The lateral acceleration sensor 47 is also fixed to a car body, and it is the acceleration GY of the longitudinal direction of a car. It detects and is this acceleration GY. The detecting signal to express is outputted. Moreover, the display-control circuit 48 and the lamp 49 are connected to the output of a microcomputer 41. A lamp 49 enables the display of green, yellow, and red, and this foreground color is controlled by the display-control circuit 48.
[0012] The microcomputer 42 has memorized the program corresponding to the flow chart of drawing 13 , and controls steering of the right-and-left rear wheels RW1 and RW2 by this program execution. Moreover, this microcomputer 42 has the table constituted by ROM, and the multiplier KY (refer to drawing 14) is memorized by this table. While said microcomputer 41 and the yaw rate sensor 45 are connected, the rear wheel steering angle sensor 51 is connected to the input of a microcomputer 42. The rear wheel rudder angle sensor 51 is rear wheel steering angle deltar by being prepared near the relay rod 32 and detecting the amount of displacement of this rod 32. It detects and is this steering angle deltar. The detecting signal to express is outputted. Moreover, the drive circuit 52 is connected to the output of this microcomputer 42, and this circuit 52 controls the drive of an actuator 31.
[0013] Next, actuation of the example constituted as mentioned above is explained. If an ignition switch (not shown) is thrown in, after performing the initialization process which starts program execution at step 100 of drawing 2 , and sets various variables as initial value at step 102, a microcomputer 41 will repeat the circulation processing which consists of steps 104-136, and will be performed.
[0014] In this circulation processing at step 104 The front-wheel steering angle sensor 43, the wheel speed sensors 44a-44d, From the lateral acceleration sensor 47 to the yaw rate sensor 45, the order acceleration sensor 46, and the front-wheel steering angle theta While inputting each detecting signal showing the wheel rotational speed VFL, VFR, VRL, and VRR, the yaw rate gamma, the order acceleration GX, and lateral acceleration GY, respectively, it is based on the vehicle speed V at step 106, and they are **** GB0, and GB1 and Tr. It reads from a table (drawing 4 - 6 reference). In this case, although the value "0" initialized at step 102 at first is used as the vehicle speed V, the value which set after that and was calculated at step 112 of the last circulation processing is used. Next, they are said **** GB0 read, and GB1 and Tr at step 108. And slip-angle beta of a car is calculated by activation of the operation based on the one following using said inputted yaw rate gamma.
[Equation 1]

$$\beta = F(s) \cdot \gamma = \frac{G_{B0} + G_{B1} \cdot s}{1 + Tr \cdot s} \cdot \gamma$$

s is the Laplacian operator among said-one number, and F (s) is a transfer function showing the relation between the yaw rate gamma and slip-angle beta of a car.
[0015] By next, activation of an operation with the two following based on said each inputted wheel rotational speed VFL, VFR, VRL, and VRR, the yaw rate gamma, and said computed slip-angle beta at step 110 Amendment wheel rotational speed V1, V2, V3, and V4 of each rings FW1, FW2, RW1, and RW2 which removed the wheel rotational-speed component of each rings FW1, FW2, RW1, and RW2 by the

revolution locus difference It calculates.
[Equation 2]
t is a tread among V1= VFL+t-gamma / 2V2= VFR-t-gamma / 2V3= VRL+t-gamma / 2+ L-beta-gamma V4= VRR-t-gamma / 2+ L-beta-gamma, in addition said-two number, and L is a wheel base. When some explanation is added about said-two number using drawing 15 , they are the amendment wheel rotational speed V1, V2, V3, and V4. Slip-angle beta of the yaw rate gamma of the circumference of the center of gravity CC of a car and a car is used for each wheel rotational speed VFL, VFR, VRL, and VRR of each rings FW1, FW2, RW1, and RW2, and it is the center position CF of the right-and-left front wheels FW1 and FW2. It converts into wheel rotational speed. Thereby, the rotational-speed difference component of each rings FW1, FW2, RW1, and RW2 by the revolution locus difference is removed.
[0016] Next, it is said acceleration GX before and after inputting at step 112. It is based and the vehicle speed V is determined according to the conditions of the following ** - **. ** order acceleration GX more than "0" and the forward predetermined value G0 with a small absolute value -- the time (0 <=GX<=G0) of being the following (for example, about 1.0 m/s2 - about 5.0 m/s2) -- the vehicle speed V -- each amendment wheel rotational speed V1, V2, V3, and V4 It is set as the minimum value MIN (V1, V2, V3, V4). ** order acceleration GX negative predetermined value-G0 with a small absolute value -- the time (-G0 <=GX<=0) of being under the above (for example, about -5.0 m/s2 - -about 1.0 m/s2) and "0" -- the vehicle speed V -- each amendment wheel rotational speed V1, V2, V3, and V4 It is set as Maximum MAX (V1, V2, V3, V4). ** Order acceleration GX Said negative predetermined value - G0 The following or said forward predetermined value G0 When large (GX <-G0 or GX>-G0), the vehicle speed V is calculated by activation of an operation with the three following.
[Equation 3] The inside of V=V0+integralGXdt, in addition said-three number, and integration constant V0 It is the amendment vehicle speed V just before fulfilling the conditions (GX <-G0 or GX>-G0) of the aforementioned **.
[0017] When each rings FW1, FW2, RW1, and RW2 will hardly have slipped by this if a car is in a fixed-speed run state, slight accelerating, or a moderation run state namely, they are the amendment wheel rotational speed V1, V2, V3, and V4 of a wheel with the lowest slip ratio. It is determined as the vehicle speed V. Moreover, when each rings FW1, FW2, RW1, and RW2 will have slipped if a car is in accelerating or a moderation run state namely, it is the car-body order acceleration GX. The vehicle speed V is determined by the used integration operator. Consequently, the vehicle speed V will be set as the exact value which does not include a revolution locus error and a slip error.
[0018] Next, they are each amendment wheel rotational speed V1, V2, V3, and V4 at step 114. By activation of an operation with the four used following, maximum slip ratio X of each rings FW1, FW2, RW1, and RW2 is calculated.
[Equation 4]

$$X = \frac{MAX(V_1, V_2, V_3, V_4) - MIN(V_1, V_2, V_3, V_4)}{AVE(V_1, V_2, V_3, V_4)}$$

In addition, the inside of said-four number and Operator AVE Each amendment wheel rotational speed V1, V2, V3, and V4 It means calculating the average. It is based on said calculated maximum slip ratio X after processing of said step 114, and at step 116, and is the 1st evaluation value LX. It reads from a table (refer to drawing 7). In this case, since the maximum slippage of the travelling direction of each rings FW1, FW2, RW1, and RW2 and a road surface, i.e., a cross direction, is expressed, maximum slip ratio X is the 1st evaluation value LX. The slippage of the cross direction of a wheel which normalized maximum to "1" is expressed.
[0019] Next, criteria lateral acceleration GY* is calculated at step 118 by activation of an operation with the

five following based on said inputted yaw rate gamma and said calculated vehicle speed V.
[Equation 5] In the six following which are GY*= gamma-V and as which this several 5 generally expresses the lateral acceleration at the time of car revolution It corresponds, when rate-of-change d beta/dt of slip-angle beta of a car is "0". By this criteria lateral acceleration GY* The car is circling in the ideal condition and the lateral acceleration of a car when the lateral slippage to the road surface of each rings FW1, FW2, RW1, and RW2 is close to "0" is expressed.
[Equation 6] GY= [gamma+ (d beta/dt)] -V [0020] It is said calculated criteria lateral acceleration GY* and said inputted lateral acceleration GY after processing of said step 118, and at step 120. By activation of an operation with the seven based following, lateral slippage Y to the road surface of a wheel is calculated, and it is based on said calculated slippage Y at step 122, and is the 2nd evaluation value LY. It reads from a table (refer to drawing 8).
[Equation 7] Y=|GY*-GY| -- the slippage of the longitudinal direction of a wheel which normalized maximum to "1" by this -- the 2nd evaluation value LY ****** -- it means that it was calculated
[0021] next, the step 124 -- the vehicle speed V -- being based -- multipliers Tr, gamma0, a, and b from a table (drawing 6 , nine to 11 reference) -- reading -- step 126 -- said read multipliers Tr, gamma0, a, and b and activation of the operation based on the eight following using said inputted front-wheel steering angle theta -- criteria yaw rate gamma* It calculates.
[Equation 8]

$$\gamma^{*} = G(s)\cdot\theta = \frac{(Tr\cdot s+1)\cdot\gamma_0}{a\cdot s^2+b\cdot s+1}\cdot\theta$$

In said-eight number, G (s) is a transfer function showing the relation between a front-wheel steering angle when the car is circling in the ideal condition, and a yaw rate, and s is the Laplacian operator. the yaw rate of the car in a condition with the slippage of the circumference of vertical axes [as opposed to the road surface of each rings FW1, FW2, RW1, and RW2 by this] near "0" -- criteria yaw rate gamma* ****** -- it means that it was calculated
[0022] It is said calculated criteria yaw rate gamma* after processing of said step 126, and at step 128. By activation of an operation with the nine following based on said inputted yaw rate gamma, slippage Z of the circumference of the center-of-gravity location vertical axes over the road surface of a wheel is calculated, and it is based on said calculated slippage Z at step 130, and is the 3rd evaluation value LZ. It reads from a table (refer to drawing 12).
[Equation 9] Z=|gamma*-gamma| -- the slippage of the circumference of the center-of-gravity location vertical axes of a wheel which normalized maximum to "1" by this -- the 3rd evaluation value LZ ****** -- it means that it was calculated
[0023] Next, they are said the 1st calculated - 3rd evaluation values LX, LY, and LZ at step 132. By activation of an operation with the ten based following, the maximum LMAX of each of said evaluation values LX, LY, and LZ is calculated.
[Equation 10] LMAX=MAX (LX, LY, LZ) [0024] Next, it is said calculated maximum LMAX at step 134. It compares with the 1st and 2nd reference values (for example, "0.5" and "0.8"), and is this maximum LMAX. It is the 1st less than reference value, or is this maximum LMAX. Whether it is the 2nd less than reference value, the 1st more than reference value of this maximum LMAX The display-control signal with which it expresses, respectively whether it is the 2nd more than reference value is outputted to the display-control circuit 48. The display-control circuit 48 is based on said display-control signal, and is Maximum LMAX. A lamp 49 will be made to turn on green if it is the 1st less than reference value. Moreover, maximum LMAX If it is the 2nd less than reference value more than per reference value [the], yellow will be made to turn on a lamp 49, and it is Maximum LMAX. If it is the 2nd more than reference value, red will

be made to turn on a lamp 49. Thereby, an operator can recognize the slip condition of a wheel visually and can make it reflected in operation of a car.

[0025] Next, it is said calculated maximum LMAX at step 136. The signal to express is outputted to a microcomputer 42. On the other hand, at the time of an injection of said ignition switch, a microcomputer 42 starts program execution at step 200 of drawing 13 , and is continuing repeating and performing circulation processing which consists of steps 204-210 after the initialization process of step 202.

[0026] Said maximum LMAX which the microcomputer 41 is outputting at step 204 in this circulation processing While inputting the signal to express, they are the yaw rate gamma from the yaw rate sensor 45 and the rear wheel steering angle sensor 51, and rear wheel steering angle deltar. The detecting signal to express is inputted. Next, it is said maximum LMAX at step 206. It is based and is the yaw rate multiplier KY. It reads from a table (refer to drawing 14), and is said yaw rate multiplier KY at step 208. And target rear wheel steering angle deltar* is calculated by activation of an operation with the 11 following based on the yaw rate gamma.

[Equation 11] deltar*= KY-gamma [0027] The control signal which expresses difference deltar*-deltar of said target rear wheel steering angle deltar* and said inputted rear wheel steering angle deltar with step 210 is outputted to an actuator 31 after count of this target yaw rate deltar*. Based on said control signal, only the amount corresponding to said difference deltar*-deltar carries out [actuator / 31] the variation rate of the relay rod 32 to right and left. With the variation rate of this relay rod 32, the right-and-left rear wheels RW1 and RW2 are steered by target rear wheel steering angle deltar*. In this case, maximum LMAX showing the slippage of said wheel Since the yaw rate multiplier KY is set up so that it may become large as it becomes large, the right-and-left rear wheels RW1 and RW2 come to be greatly steered by the inphase to the right-and-left front wheels FW1 and FW2, and a car is controlled by the stable inclination as the slippage of a wheel becomes large.

[0028] In addition, although the slip condition of a wheel was displayed by difference of the lighting color of a lamp 49, you may make it display this slip condition in the above-mentioned example according to each condition of putting out lights of a lamp 49, flashing, and lighting. In this case, the display-control circuit 48 is Maximum LMAX. If it is the 1st less than reference value, a lamp 49 will be switched off, and it is Maximum LMAX. If it is the 2nd less than reference value more than per reference value [the], a lamp 49 will be blinked, and it is Maximum LMAX. What is necessary is just to make it turn on a lamp 49, if it is the 2nd more than reference value.

[0029] Moreover, although the vehicle speed V was detected using the detected wheel rotational speed VFL, VFR, VRL, and VRR, the yaw rate gamma, and the order acceleration GX (steps 104-112), you may make it detect in the above-mentioned example based on the rotational speed of the output shaft of an option, for example, a change gear.

[0030] Moreover, in the above-mentioned example, although only the example which applied the slip condition evaluation equipment of the wheel concerning this invention to the rear wheel power steering system 30 was explained, it is in ** that this invention is applicable also to various control of cars, such as suspension equipment and anti-lock brake equipment.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to the slip condition evaluation equipment of the wheel which can be used for the various control units of the car which controls the warning device which tells an operator about the slip condition of a wheel or the steering property of a car, a drive property, etc. by starting the slip condition evaluation equipment of a wheel by which the slip condition of a wheel is evaluated, especially evaluating said slip condition, and enabling it to output.

[Translation done.]

PRIOR ART

[Description of the Prior Art] While detecting from the former that the wheel has slipped, enabling it to run by answering this detection, controlling the brake oil pressure given to a wheel at the time of car braking, restricting the acceleration at the time of car revolution, or controlling the steer property of a car, and stabilizing a car is known well. And if in charge of detection of the slip condition of a wheel in this case, he is trying to detect the slip (slipping) of a wheel based on the rotational speed of a wheel. (For example, refer to JP,62-146762,A)

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Like the above-mentioned operation explanation, while the slippage of the wheel of a cross direction is calculated as the 1st evaluation value according to the description on the 1st [of this invention] configuration, the slippage of a lateral wheel is calculated as the 2nd evaluation value, and the maximum of these 1st and 2nd evaluation values is drawn as a final evaluation value of the slip condition of a wheel. Therefore, according to the description on the 1st [of this this invention] configuration, the evaluation value as which not only slipping of the cross direction on the road surface of a wheel but slipping over a longitudinal direction was considered will be calculated, and the slip condition of a wheel can evaluate now correctly and easily using a numeric value. Moreover, according to the description on the 2nd [of this invention] configuration, while the slippage of the wheel of a cross direction is calculated as the 1st evaluation value, the slippage of the wheel of the circumference of vertical axes is calculated as the 2nd evaluation value, and the maximum of these 1st and 2nd evaluation values is drawn as a final evaluation value of the slip condition of a wheel. Therefore, according to the description on the 2nd [of this this invention] configuration, the evaluation value as which not only slipping of the cross direction on the road surface of a wheel but slipping over the circumference of vertical axes was considered will be calculated, and the slip condition of a wheel can evaluate now correctly and easily using a numeric value. Moreover, according to the description on the 3rd [of this invention] configuration, while the slippage of the wheel of the circumference of a cross direction, a longitudinal direction, and vertical axes is calculated as the 1st - the 3rd evaluation value, the maximum of these the 1st - 3rd evaluation values is drawn as a final evaluation value of the slip condition of a wheel. Therefore, according to the description on the 3rd [of this this invention] configuration, the evaluation value as which slipping over all the directions of [on the road surface of a wheel] was considered will be calculated, and the slip condition of a wheel can evaluate now more correctly and easily using a numeric value.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, even if lateral slipping arose for the wheel or slipping of the circumference of vertical axes arose for the wheel since the slip condition of a wheel was detected based on the rotational speed of a wheel, i.e., slipping of a cross direction, if it was in the above-mentioned conventional equipment, these slipping could not be detected exactly and the slip condition of a wheel was not able to be evaluated correctly. It was made in order that this invention might cope with the above-mentioned problem, and the purpose is in offering the slip condition evaluation equipment of a wheel by which the slip condition of a wheel is evaluated correctly.

[Translation done.]

MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the description on the 1st [of this invention] configuration A wheel speed detection means to detect each rotational speed of two or more wheels, respectively (it corresponds to the wheel speed sensors 44a-44d of an example), A vehicle speed detection means to detect the vehicle speed (it corresponds to processing of the wheel speed sensors 44a-44d of an example, the yaw rate sensor 45, the order acceleration sensor 46, and steps 106-112), A lateral acceleration detection means to detect the lateral acceleration of a car (it corresponds to the lateral acceleration sensor 47 of an example), A yaw rate detection means to detect the yaw rate of a car (it corresponds to the yaw rate sensor 45 of an example), A 1st evaluation value count means to calculate the 1st evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of a cross direction to the difference of **** rotational speed based on said each detected rotational speed (it corresponds to processing of step 114,116 of an example), A criteria lateral acceleration count means to calculate ideal lateral acceleration as criteria lateral acceleration for a revolution car based on said detected vehicle speed and said detected yaw rate (it corresponds to processing of step 118 of an example), A 2nd evaluation value count means to calculate the 2nd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the longitudinal direction of a wheel to the difference of **** lateral acceleration based on the difference of said detected lateral acceleration and said calculated criteria lateral acceleration (it corresponds to processing of step 120,122 of an example), It is in having had a slip condition evaluation value derivation means (it corresponding to processing of step 132 of an example) to derive the maximum of said calculated 1st and 2nd evaluation values as an evaluation value of the slip condition of a wheel. Moreover, a wheel speed detection means by which the description on the 2nd [of this invention] configuration detects each rotational speed of two or more wheels, respectively (it corresponds to the wheel speed sensors 44a-44d of an example), A vehicle speed detection means to detect the vehicle speed (it corresponds to processing of the wheel speed sensors 44a-44d of an example, the yaw rate sensor 45, the order acceleration sensor 46, and steps 106-112), A steering angle detection means to detect the steering angle of a front wheel (it corresponds to the front-wheel steering angle sensor 43 of an example), A yaw rate detection means to detect the yaw rate of a car (it corresponds to the yaw rate sensor 45 of an example), A 1st evaluation value count means to calculate the 1st evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of a cross direction to the difference of **** rotational speed based on said each detected rotational speed (it corresponds to processing of step 114,116 of an example), A criteria yaw rate count means to calculate an ideal yaw rate as a criteria yaw rate for a revolution car based on said detected vehicle speed and said detected steering angle (it corresponds to processing of step 124,126 of an example), A 2nd evaluation value count means to calculate the 2nd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of the circumference of vertical axes to the difference of a **** yaw rate based on the difference of said detected yaw rate and said calculated criteria yaw rate (it corresponds to processing of step 128,130 of an example), It is in having had a slip condition

evaluation value derivation means (it corresponding to processing of step 132 of an example) to derive the maximum of said calculated 1st and 2nd evaluation values as an evaluation value of the slip condition of a wheel. Moreover, a wheel speed detection means by which the description on the 3rd [of this invention] configuration detects each rotational speed of two or more wheels, respectively (it corresponds to the wheel speed sensors 44a-44d of an example), A vehicle speed detection means to detect the vehicle speed (it corresponds to processing of the wheel speed sensors 44a-44d of an example, the yaw rate sensor 45, the order acceleration sensor 46, and steps 106-112), A steering angle detection means to detect the steering angle of a front wheel (it corresponds to the front-wheel steering angle sensor 43 of an example), A lateral acceleration detection means to detect the lateral acceleration of a car (it corresponds to the lateral acceleration sensor 47 of an example), A yaw rate detection means to detect the yaw rate of a car (it corresponds to the yaw rate sensor 45 of an example), A 1st evaluation value count means to calculate the 1st evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of a cross direction to the difference of **** rotational speed based on said each detected rotational speed (it corresponds to processing of step 114,116 of an example), A criteria lateral acceleration count means to calculate ideal lateral acceleration as criteria lateral acceleration for a revolution car based on said detected vehicle speed and said detected yaw rate (it corresponds to processing of step 118 of an example), A 2nd evaluation value count means to calculate the 2nd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the longitudinal direction of a wheel to the difference of **** lateral acceleration based on the difference of said detected lateral acceleration and said calculated criteria lateral acceleration (it corresponds to processing of step 120,122 of an example), A criteria yaw rate count means to calculate an ideal yaw rate as a criteria yaw rate for a revolution car based on said detected vehicle speed and said detected steering angle (it corresponds to processing of step 124,126 of an example), A 3rd evaluation value count means to calculate the 3rd evaluation value which carries out proportionally [abbreviation] and expresses the slippage of the wheel of the circumference of vertical axes to the difference of a **** yaw rate based on the difference of said detected yaw rate and said calculated criteria yaw rate (it corresponds to processing of step 128,130 of an example), It is in having had a slip condition evaluation value derivation means (it corresponding to processing of step 132 of an example) to derive the maximum of said the 1st calculated thru/or 3rd evaluation values as an evaluation value of the slip condition of a wheel.

[Translation done.]

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OPERATION

[Function] In the 1st description of this invention constituted as mentioned above, If slipping arises between a wheel and a road surface in the travelling direction (cross direction) of a wheel at the time of the acceleration and deceleration of a car etc. The difference corresponding to said slippage arises between each rotational speed of two or more wheels, and the slippage of the wheel of this cross direction is calculated by the difference of each of said rotational speed as the 1st evaluation value which carried out proportionally [abbreviation] based on each rotational speed of the wheel detected by the wheel speed detection means with the 1st evaluation value count means. Moreover, if the car is circling in the ideal condition (condition that the slippage of a lateral wheel is small), for a car, ideal lateral acceleration will become settled at the vehicle speed and a yaw rate, and this lateral acceleration will be calculated as criteria lateral acceleration with a criteria lateral acceleration count means based on the yaw rate detected by the vehicle speed and the yaw rate detection means which were detected by the vehicle speed detection means. On the other hand, if lateral slipping arises between a wheel and a road surface during car revolution, the difference corresponding to said slippage will arise between the actual lateral acceleration of a car, and said criteria lateral acceleration. It is and the slippage of the wheel of this longitudinal direction is calculated by the difference of **** lateral acceleration as the 2nd evaluation value which carried out proportionally [abbreviation] based on the difference of the lateral acceleration detected by the lateral acceleration detection means with the 2nd evaluation value count means, and said calculated criteria lateral acceleration. And the maximum of said calculated 1st and 2nd evaluation values is drawn as an evaluation value of a slip condition by the slip condition evaluation value derivation means. Moreover, in the 2nd description of this invention constituted as mentioned above, although it is the same about count of the 1st evaluation value, count of the 2nd evaluation value in the description on said 1st configuration differs. That is, if the car is circling in the ideal condition (condition that the slippage of a lateral wheel is small), for a car, an ideal yaw rate will become settled on the vehicle speed and the steering square of a front wheel, and this yaw rate will be calculated as a criteria yaw rate with a criteria yaw rate count means based on the steering angle of the front wheel detected by the vehicle speed and the steering angle detection means which were detected by the vehicle speed detection means. If slipping of the circumference of vertical axes arises between a wheel and a road surface during car revolution on the other hand, The difference corresponding to said slippage arises between the actual yaw rate of a car, and said criteria yaw rate, and the slippage of the wheel of the circumference of these vertical axes is calculated by the difference of a **** yaw rate as the 2nd evaluation value which carried out proportionally [abbreviation] based on the yaw rate detected by the yaw rate detection means with the 2nd evaluation value count means, and said calculated criteria yaw rate. And also in this 2nd description, the maximum of said calculated 1st and 2nd evaluation values is drawn as an evaluation value of a slip condition by the slip condition evaluation value derivation means. Furthermore, it sets with the 3rd description of this invention constituted as mentioned above, While the 1st and 2nd evaluation value is calculated by carrying out like said 1st description, the 2nd evaluation value of said 2nd description is calculated as the 3rd evaluation

value, and the maximum of said the 1st calculated thru/or 3rd evaluation values is drawn as an evaluation value of a slip condition by the slip condition evaluation value derivation means.

[Translation done.]

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EXAMPLE

[Example] Hereafter, if one example of this invention is explained using a drawing, drawing 1 shows roughly the whole four-flower steering vehicle which applied the slip condition evaluation equipment of the wheel concerning this invention. This four-flower steering vehicle is equipped with the front-wheel power steering system 20 which steers the right-and-left front wheels FW1 and FW2, the rear wheel power steering system 30 which steers the right-and-left rear wheels RW1 and RW2, and the electrical control unit 40 which controls the rear wheel power steering system 30 electrically.
[0008] The front-wheel power steering system 20 is equipped with the steering shaft 22 which fixed the handle 21 to upper limit. The lower limit of the steering shaft 22 is connected to the rack bar 24 supported possible [the displacement to shaft orientations] in the steering gearbox 23, and this bar 24 is displaced to shaft orientations according to rotation of a handle 21. The right-and-left front wheels FW1 and FW2 are connected to the both ends of the rack bar 24 through tie rods 25a and 25b and steering knuckle arms 26a and 26b, and the right-and-left front wheels FW1 and FW2 are steered according to the variation rate of the shaft orientations of the rack bar 24.
[0009] The rear wheel power steering system 30 is equipped with the actuator 31 controlled electrically, and this actuator 31 drives the relay rod 32 prepared in shaft orientations possible [displacement] to shaft orientations. The right-and-left rear wheels RW1 and RW2 are connected to the both ends of the relay rod 32 through tie rods 33a and 33b and steering knuckle arms 34a and 34b, and the right-and-left rear wheels RW1 and RW2 are steered according to the variation rate of the shaft orientations of the relay rod 32.
[0010] The electrical control unit 40 is equipped with microcomputers 41 and 42. The microcomputer 41 has memorized the program corresponding to drawing 2 and the flow chart of 3, and evaluates the slip condition of each rings FW1, FW2, RW1, and RW2 by this program execution. Moreover, this microcomputer 41 has the table constituted by ROM, and the various multipliers and the evaluation values GB0, GB1, Tr, LX, LY, gamma0, a, b, and LZ (drawing 4 - 12 reference) which are used for this table at the time of said program execution are memorized.
[0011] The front-wheel steering angle sensor 43, the wheel speed sensors 44a-44d, the yaw rate sensor 45, the order acceleration sensor 46, and the lateral acceleration sensor 47 are connected to the input of a microcomputer 41. The front-wheel steering angle sensor 43 is attached to the steering shaft 22, detects the front-wheel steering angle theta by detecting the angle of rotation of the same axle 22, and outputs the detecting signal showing this steering angle theta. It is prepared near each rings FW1, FW2, RW1, and RW2, the rotational speed VFL, VFR, VRL, and VRR of each rings FW1, FW2, RW1, and RW2 is detected, and the wheel speed sensors 44a-44d are these rotational speed VFL, VFR, VRL, and VRR. The detecting signal to express is outputted, respectively. It is fixed to the center-of-gravity location of a car body, and the yaw rate sensor 45 detects the yaw rate gamma by detecting the angular rate of rotation of the car body of the circumference of vertical axes, and outputs the detecting signal showing this yaw rate gamma. The order acceleration sensor 46 is also fixed to a car body, and it is the acceleration GX of the cross direction of a car. It detects and is this acceleration GX. The detecting signal to express is outputted. The lateral

acceleration sensor 47 is also fixed to a car body, and it is the acceleration GY of the longitudinal direction of a car. It detects and is this acceleration GY. The detecting signal to express is outputted. Moreover, the display-control circuit 48 and the lamp 49 are connected to the output of a microcomputer 41. A lamp 49 enables the display of green, yellow, and red, and this foreground color is controlled by the display-control circuit 48.
[0012] The microcomputer 42 has memorized the program corresponding to the flow chart of drawing 13 , and controls steering of the right-and-left rear wheels RW1 and RW2 by this program execution. Moreover, this microcomputer 42 has the table constituted by ROM, and the multiplier KY (refer to drawing 14) is memorized by this table. While said microcomputer 41 and the yaw rate sensor 45 are connected, the rear wheel steering angle sensor 51 is connected to the input of a microcomputer 42. The rear wheel rudder angle sensor 51 is rear wheel steering angle deltar by being prepared near the relay rod 32 and detecting the amount of displacement of this rod 32. It detects and is this steering angle deltar. The detecting signal to express is outputted. Moreover, the drive circuit 52 is connected to the output of this microcomputer 42, and this circuit 52 controls the drive of an actuator 31.
[0013] Next, actuation of the example constituted as mentioned above is explained. If an ignition switch (not shown) is thrown in, after performing the initialization process which starts program execution at step 100 of drawing 2 , and sets various variables as initial value at step 102, a microcomputer 41 will repeat the circulation processing which consists of steps 104-136, and will be performed.
[0014] In this circulation processing at step 104 The front-wheel steering angle sensor 43, the wheel speed sensors 44a-44d, From the lateral acceleration sensor 47 to the yaw rate sensor 45, the order acceleration sensor 46, and the front-wheel steering angle theta While inputting each detecting signal showing the wheel rotational speed VFL, VFR, VRL, and VRR, the yaw rate gamma, the order acceleration GX, and lateral acceleration GY, respectively, it is based on the vehicle speed V at step 106, and they are **** GB0, and GB1 and Tr. It reads from a table (drawing 4 - 6 reference). In this case, although the value "0" initialized at step 102 at first is used as the vehicle speed V, the value which set after that and was calculated at step 112 of the last circulation processing is used. Next, they are said **** GB0 read, and GB1 and Tr at step 108. And slip-angle beta of a car is calculated by activation of the operation based on the one following using said inputted yaw rate gamma.
[Equation 1]

$$\beta = F(s)\cdot\gamma = \frac{G_{B0} + G_{B1}\cdot s}{1 + Tr\cdot s}\cdot\gamma$$

s is the Laplacian operator among said-one number, and F (s) is a transfer function showing the relation between the yaw rate gamma and slip-angle beta of a car.
[0015] By next, activation of an operation with the two following based on said each inputted wheel rotational speed VFL, VFR, VRL, and VRR, the yaw rate gamma, and said computed slip-angle beta at step 110 Amendment wheel rotational speed V1, V2, V3, and V4 of each rings FW1, FW2, RW1, and RW2 which removed the wheel rotational-speed component of each rings FW1, FW2, RW1, and RW2 by the revolution locus difference It calculates.
[Equation 2]
t is a tread among V1= VFL+t-gamma / 2V2= VFR-t-gamma / 2V3= VRL+t-gamma / 2+ L-beta-gamma V4= VRR-t-gamma / 2+ L-beta-gamma, in addition said-two number, and L is a wheel base. When some explanation is added about said-two number using drawing 15 , they are the amendment wheel rotational speed V1, V2, V3, and V4. Slip-angle beta of the yaw rate gamma of the circumference of the center of gravity CC of a car and a car is used for each wheel rotational speed VFL, VFR, VRL, and VRR of each

rings FW1, FW2, RW1, and RW2, and it is the center position CF of the right-and-left front wheels FW1 and FW2. It converts into wheel rotational speed. Thereby, the rotational-speed difference component of each rings FW1, FW2, RW1, and RW2 by the revolution locus difference is removed.
[0016] Next, it is said acceleration GX before and after inputting at step 112. It is based and the vehicle speed V is determined according to the conditions of the following ** - **. ** order acceleration GX more than "0" and the forward predetermined value G0 with a small absolute value -- the time (0 <=GX<=G0) of being the following (for example, about 1.0 m/s2 - about 5.0 m/s2) -- the vehicle speed V -- each amendment wheel rotational speed V1, V2, V3, and V4 It is set as the minimum value MIN (V1, V2, V3, V4). ** order acceleration GX negative predetermined value-G0 with a small absolute value -- the time (-G0 <=GX<=0) of being under the above (for example, about -5.0 m/s2 - -about 1.0 m/s2) and "0" -- the vehicle speed V -- each amendment wheel rotational speed V1, V2, V3, and V4 It is set as Maximum MAX (V1, V2, V3, V4). ** Order acceleration GX Said negative predetermined value - G0 The following or said forward predetermined value G0 When large (GX <-G0 or GX>-G0), the vehicle speed V is calculated by activation of an operation with the three following.
[Equation 3] The inside of V=V0+integralGXdt, in addition said-three number, and integration constant V0 It is the amendment vehicle speed V just before fulfilling the conditions (GX <-G0 or GX>-G0) of the aforementioned **.
[0017] When each rings FW1, FW2, RW1, and RW2 will hardly have slipped by this if a car is in a fixed-speed run state, slight accelerating, or a moderation run state namely, they are the amendment wheel rotational speed V1, V2, V3, and V4 of a wheel with the lowest slip ratio. It is determined as the vehicle speed V. Moreover, when each rings FW1, FW2, RW1, and RW2 will have slipped if a car is in accelerating or a moderation run state namely, it is the car-body order acceleration GX. The vehicle speed V is determined by the used integration operator. Consequently, the vehicle speed V will be set as the exact value which does not include a revolution locus error and a slip error.
[0018] Next, they are each amendment wheel rotational speed V1, V2, V3, and V4 at step 114. By activation of an operation with the four used following, maximum slip ratio X of each rings FW1, FW2, RW1, and RW2 is calculated.
[Equation 4]

$$X = \frac{MAX(V_1, V_2, V_3, V_4) - MIN(V_1, V_2, V_3, V_4)}{AVE(V_1, V_2, V_3, V_4)}$$

In addition, the inside of said-four number and Operator AVE Each amendment wheel rotational speed V1, V2, V3, and V4 It means calculating the average. It is based on said calculated maximum slip ratio X after processing of said step 114, and at step 116, and is the 1st evaluation value LX. It reads from a table (refer to drawing 7). In this case, since the maximum slippage of the travelling direction of each rings FW1, FW2, RW1, and RW2 and a road surface, i.e., a cross direction, is expressed, maximum slip ratio X is the 1st evaluation value LX. The slippage of the cross direction of a wheel which normalized maximum to "1" is expressed.
[0019] Next, criteria lateral acceleration GY* is calculated at step 118 by activation of an operation with the five following based on said inputted yaw rate gamma and said calculated vehicle speed V.
[Equation 5] In the six following which are GY*= gamma-V and as which this several 5 generally expresses the lateral acceleration at the time of car revolution It corresponds, when rate-of-change d beta/dt of slip-angle beta of a car is "0". By this criteria lateral acceleration GY* The car is circling in the ideal condition and the lateral acceleration of a car when the lateral slippage to the road surface of each rings FW1, FW2, RW1, and RW2 is close to "0" is expressed.
[Equation 6] GY= [gamma+ (d beta/dt)] -V [0020] It is said calculated criteria lateral acceleration GY* and

said inputted lateral acceleration GY after processing of said step 118, and at step 120. By activation of an operation with the seven based following, lateral slippage Y to the road surface of a wheel is calculated, and it is based on said calculated slippage Y at step 122, and is the 2nd evaluation value LY. It reads from a table (refer to drawing 8).
[Equation 7] Y=|GY*-GY| -- the slippage of the longitudinal direction of a wheel which normalized maximum to "1" by this -- the 2nd evaluation value LY ****** -- it means that it was calculated
[0021] next, the step 124 -- the vehicle speed V -- being based -- multipliers Tr, gamma0, a, and b from a table (drawing 6 , nine to 11 reference) -- reading -- step 126 -- said read multipliers Tr, gamma0, a, and b and activation of the operation based on the eight following using said inputted front-wheel steering angle theta -- criteria yaw rate gamma* It calculates.
[Equation 8]

$$\gamma^{*} = G(s)\cdot\theta = \frac{(Tr\cdot s+1)\cdot\gamma_0}{a\cdot s^2 + b\cdot s + 1}\cdot\theta$$

In said-eight number, G (s) is a transfer function showing the relation between a front-wheel steering angle when the car is circling in the ideal condition, and a yaw rate, and s is the Laplacian operator. the yaw rate of the car in a condition with the slippage of the circumference of vertical axes [as opposed to the road surface of each rings FW1, FW2, RW1, and RW2 by this] near "0" -- criteria yaw rate gamma* ****** -- it means that it was calculated
[0022] It is said calculated criteria yaw rate gamma* after processing of said step 126, and at step 128. By activation of an operation with the nine following based on said inputted yaw rate gamma, slippage Z of the circumference of the center-of-gravity location vertical axes over the road surface of a wheel is calculated, and it is based on said calculated slippage Z at step 130, and is the 3rd evaluation value LZ. It reads from a table (refer to drawing 12).
[Equation 9] Z=|gamma*-gamma| -- the slippage of the circumference of the center-of-gravity location vertical axes of a wheel which normalized maximum to "1" by this -- the 3rd evaluation value LZ ****** -- it means that it was calculated
[0023] Next, they are said the 1st calculated - 3rd evaluation values LX, LY, and LZ at step 132. By activation of an operation with the ten based following, the maximum LMAX of each of said evaluation values LX, LY, and LZ is calculated.
[Equation 10] LMAX=MAX (LX, LY, LZ) [0024] Next, it is said calculated maximum LMAX at step 134. It compares with the 1st and 2nd reference values (for example, "0.5" and "0.8"), and is this maximum LMAX. It is the 1st less than reference value, or is this maximum LMAX. Whether it is the 2nd less than reference value, the 1st more than reference value of this maximum LMAX The display-control signal with which it expresses, respectively whether it is the 2nd more than reference value is outputted to the display-control circuit 48. The display-control circuit 48 is based on said display-control signal, and is Maximum LMAX. A lamp 49 will be made to turn on green if it is the 1st less than reference value. Moreover, maximum LMAX If it is the 2nd less than reference value more than per reference value [the], yellow will be made to turn on a lamp 49, and it is Maximum LMAX. If it is the 2nd more than reference value, red will be made to turn on a lamp 49. Thereby, an operator can recognize the slip condition of a wheel visually and can make it reflected in operation of a car.
[0025] Next, it is said calculated maximum LMAX at step 136. The signal to express is outputted to a microcomputer 42. On the other hand, at the time of an injection of said ignition switch, a microcomputer 42 starts program execution at step 200 of drawing 13 , and is continuing repeating and performing circulation processing which consists of steps 204-210 after the initialization process of step 202.
[0026] Said maximum LMAX which the microcomputer 41 is outputting at step 204 in this circulation

processing While inputting the signal to express, they are the yaw rate gamma from the yaw rate sensor 45 and the rear wheel steering angle sensor 51, and rear wheel steering angle deltar. The detecting signal to express is inputted. Next, it is said maximum LMAX at step 206. It is based and is the yaw rate multiplier KY. It reads from a table (refer to drawing 14), and is said yaw rate multiplier KY at step 208. And target rear wheel steering angle deltar* is calculated by activation of an operation with the 11 following based on the yaw rate gamma.
[Equation 11] deltar*= KY-gamma [0027] The control signal which expresses difference deltar*-deltar of said target rear wheel steering angle deltar* and said inputted rear wheel steering angle deltar with step 210 is outputted to an actuator 31 after count of this target yaw rate deltar*. Based on said control signal, only the amount corresponding to said difference deltar*-deltar carries out [actuator / 31] the variation rate of the relay rod 32 to right and left. With the variation rate of this relay rod 32, the right-and-left rear wheels RW1 and RW2 are steered by target rear wheel steering angle deltar*. In this case, maximum LMAX showing the slippage of said wheel Since the yaw rate multiplier KY is set up so that it may become large as it becomes large, the right-and-left rear wheels RW1 and RW2 come to be greatly steered by the inphase to the right-and-left front wheels FW1 and FW2, and a car is controlled by the stable inclination as the slippage of a wheel becomes large.
[0028] In addition, although the slip condition of a wheel was displayed by difference of the lighting color of a lamp 49, you may make it display this slip condition in the above-mentioned example according to each condition of putting out lights of a lamp 49, flashing, and lighting. In this case, the display-control circuit 48 is Maximum LMAX. If it is the 1st less than reference value, a lamp 49 will be switched off, and it is Maximum LMAX. If it is the 2nd less than reference value more than per reference value [the], a lamp 49 will be blinked, and it is Maximum LMAX. What is necessary is just to make it turn on a lamp 49, if it is the 2nd more than reference value.
[0029] Moreover, although the vehicle speed V was detected using the detected wheel rotational speed VFL, VFR, VRL, and VRR, the yaw rate gamma, and the order acceleration GX (steps 104-112), you may make it detect in the above-mentioned example based on the rotational speed of the output shaft of an option, for example, a change gear.
[0030] Moreover, in the above-mentioned example, although only the example which applied the slip condition evaluation equipment of the wheel concerning this invention to the rear wheel power steering system 30 was explained, it is in ** that this invention is applicable also to various control of cars, such as suspension equipment and anti-lock brake equipment.

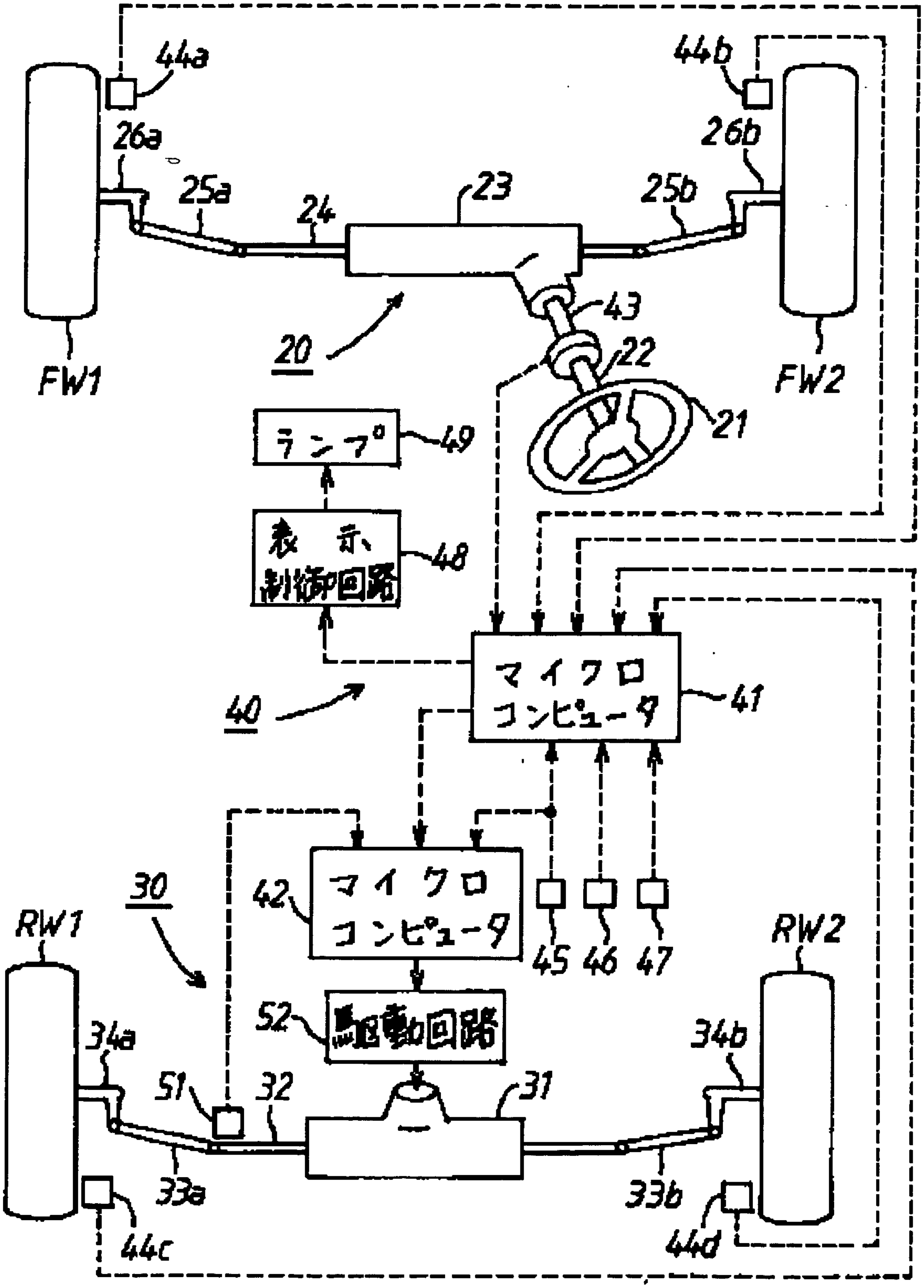
[Translation done.]

* NOTICES *

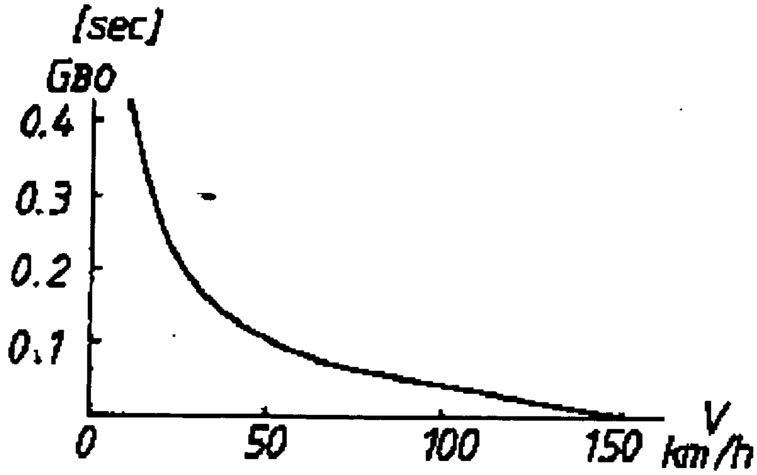
DESCRIPTION OF DRAWINGS

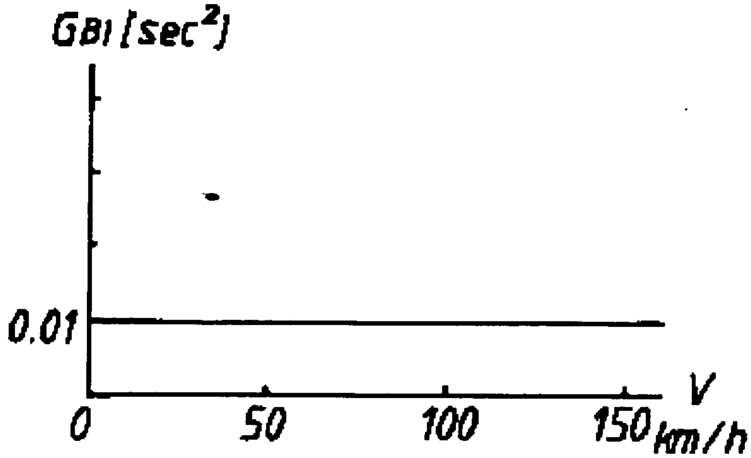
[Brief Description of the Drawings]
[Drawing 1] It is the whole car schematic diagram showing one example of this invention.
[Drawing 2] It is a part of flow chart corresponding to the program performed with one microcomputer of drawing 1 .
[Drawing 3] They are other parts of the flow chart corresponding to said program.
[Drawing 4] It is the property graph of **** GB0 which is memorized by one microcomputer of drawing 1 and used for an operation.
[Drawing 5] It is the property graph of **** GB1 which carries out by one microcomputer of drawing 1 memorizing, and is used for an operation.
[Drawing 6] Multiplier Tr which is memorized by one microcomputer of drawing 1 and used for an operation It is a property graph.
[Drawing 7] The 1st evaluation value [as opposed to / one microcomputer of drawing 1 memorizes and / maximum slip ratio X] LX It is the graph which shows a change property.
[Drawing 8] The 2nd evaluation value [as opposed to / one microcomputer of drawing 1 memorizes and / lateral slippage Y] LY It is the graph which shows a change property.
[Drawing 9] Multiplier gamma 0 which is memorized by one microcomputer of drawing 1 and used for an operation It is a property graph.
[Drawing 10] It is the property graph of the multiplier a which is memorized by one microcomputer of drawing 1 and used for an operation.
[Drawing 11] It is the property graph of the multiplier b which is memorized by one microcomputer of drawing 1 and used for an operation.
[Drawing 12] The 3rd evaluation value [as opposed to / one microcomputer of drawing 1 memorizes and / slippage Z of the circumference of car center-of-gravity location vertical axes] LZ It is the graph which shows a change property.
[Drawing 13] It is a flow chart corresponding to the program performed with the microcomputer of another side of drawing 1 .
[Drawing 14] Multiplier KY which is memorized by the microcomputer of another side of drawing 1 and is used for an operation It is a property graph.
[Drawing 15] It is the explanatory view showing the relation between the wheel rotational speed VFL, VFR, VRL, and VRR, the amendment wheel rotational speed V1-V4, the yaw rate gamma, and slip-angle beta.
[Description of Notations]
FW1, FW2 [-- A rear wheel power steering system, 40 / -- 41 An electrical control unit, 42 / -- A microcomputer 43 / -- A front-wheel steering angle sensor, 44a-44d / -- A wheel speed sensor, 45 / -- A yaw rate sensor, 46 / -- An order acceleration sensor, 47 / -- A lateral acceleration sensor, 49 / -- A lamp 51 / -- Rear wheel steering angle sensor.] -- A front wheel, RW1, RW2 -- A rear wheel, 20 -- A front-wheel power steering system, 30

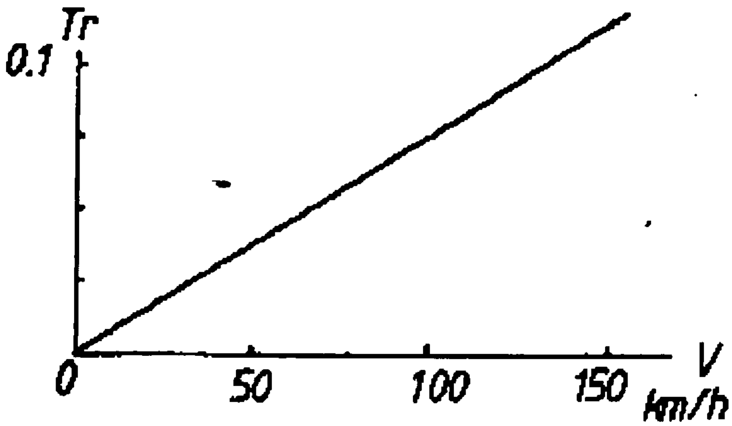
[Translation done.]

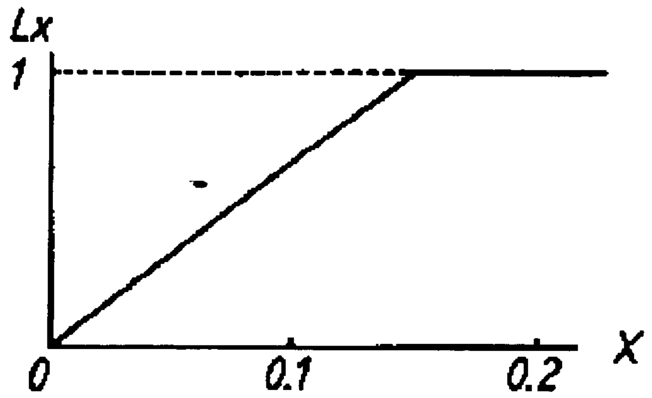


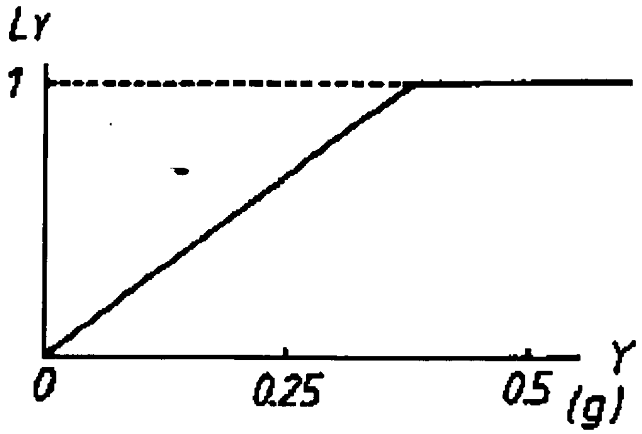
FW1，FW2…前輪　　43…前輪操舵角センサ
RW1，RW2…後輪　　44a～44d…車輪速センサ
20…前輪操舵装置　　45…ヨーレートセンサ

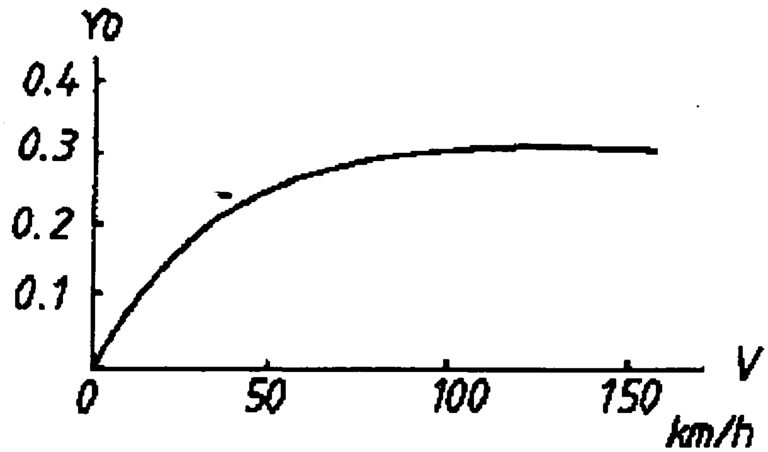

[sec]
GBO
0.4
0.3
0.2
0.1
0
50
100
150
V
km/h


GBI [sec²]
0.01
V
0
50
100
150
km/h

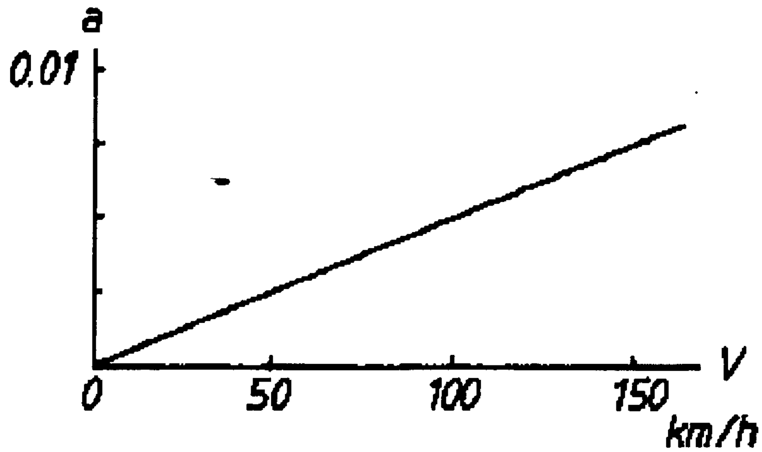

Tr
0.1
0
50
100
150
V
km/h

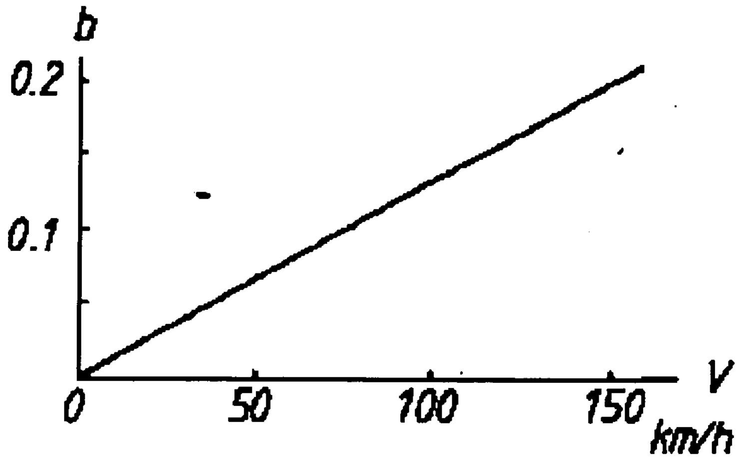

Lx
1
0
0.1
0.2
X

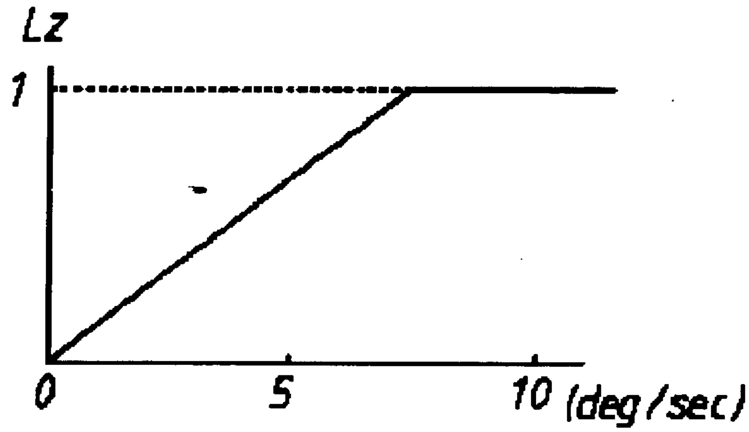

LY
1
0
0.25
0.5
Y
(g)

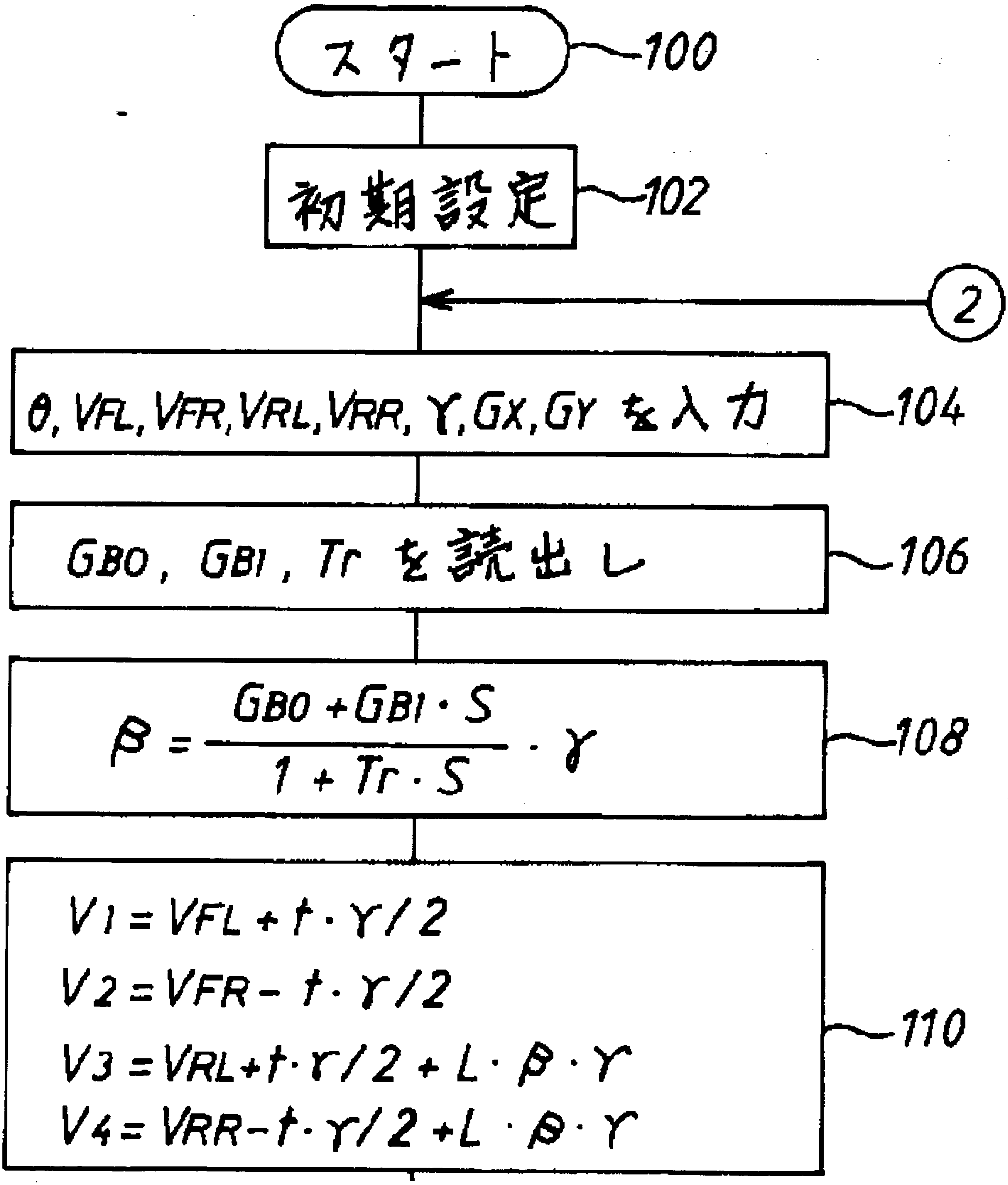


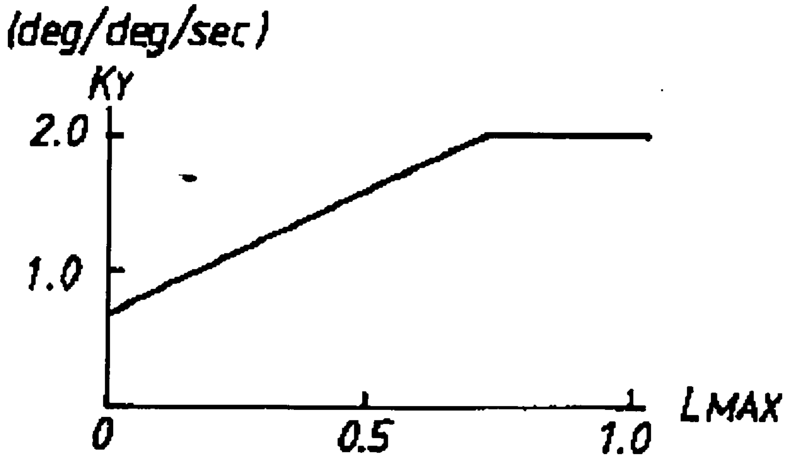
Y0
0.4
0.3
0.2
0.1
0
50
100
150
V
km/h

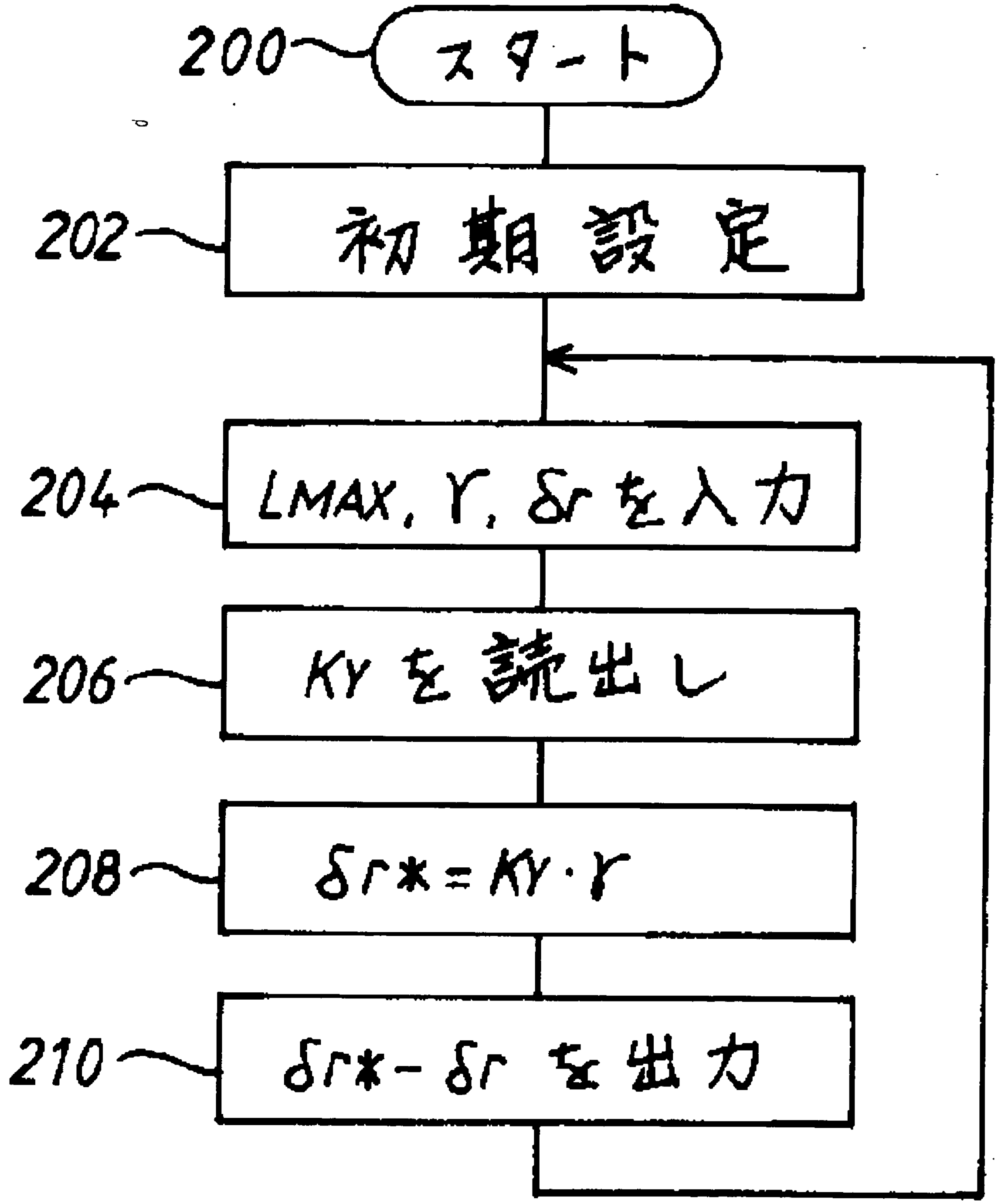

a
0.01
0
50
100
150
V
km/h


b
0.2
0.1
0
50
100
150
V
km/h


Lz
1
0
5
10 (deg/sec)


スタート
100
初期設定
102
2
θ, VFL, VFR, VRL, VRR, γ, GX, GY を入力
104
GB0, GB1, Tr を読出し
106
$\beta = \frac{G_{B0} + G_{B1} \cdot S}{1 + T_r \cdot S} \cdot \gamma$
108
$V_1 = V_{FL} + t \cdot \gamma / 2$
$V_2 = V_{FR} - t \cdot \gamma / 2$
$V_3 = V_{RL} + t \cdot \gamma / 2 + L \cdot \beta \cdot \gamma$
$V_4 = V_{RR} - t \cdot \gamma / 2 + L \cdot \beta \cdot \gamma$
110


(deg/deg/sec)
KY
2.0
1.0
0
0.5
1.0
LMAX


200 スタート
202 初期設定
204 LMAX, γ, δr を入力
206 Kγ を読出し
208 δr* = Kγ·γ
210 δr* − δr を出力

1

$G_Y{*} = \gamma \cdot V$ 118

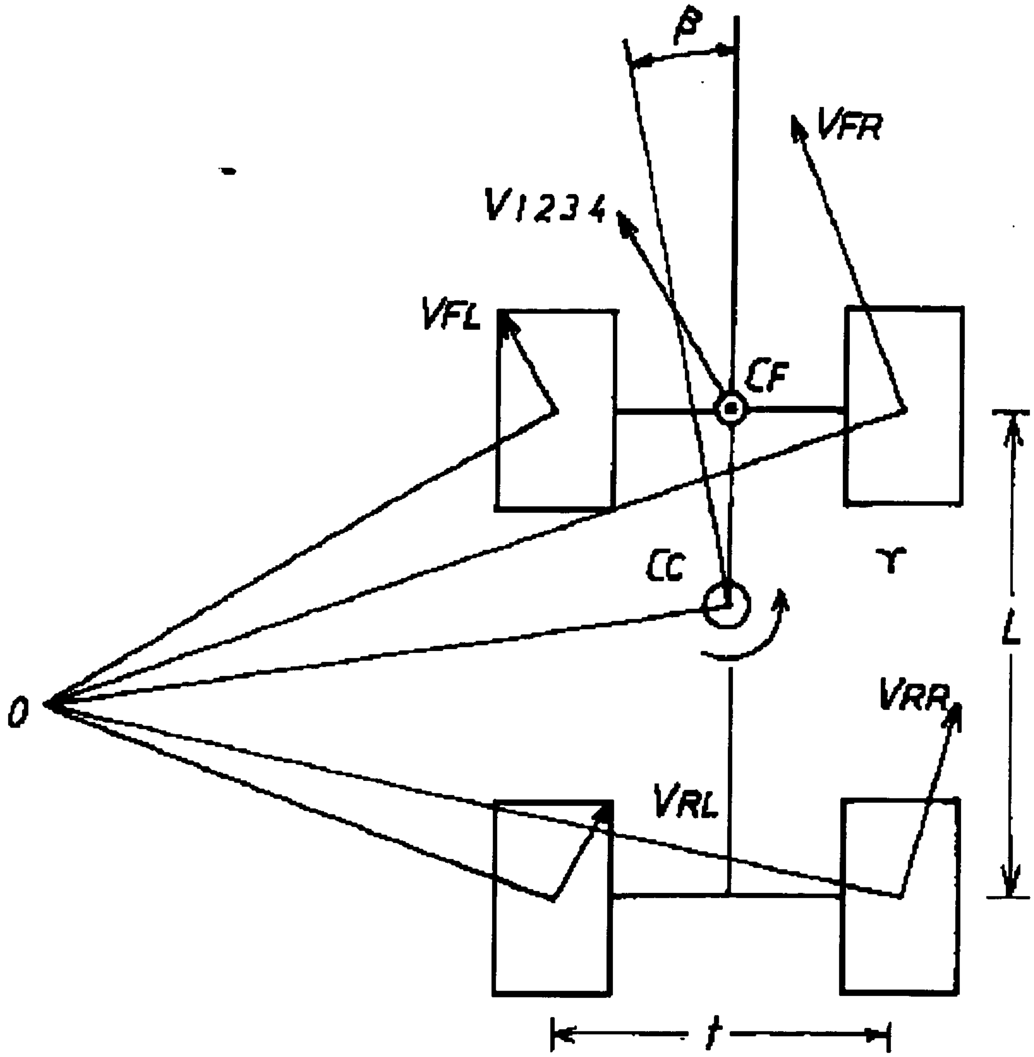
$Y = | G_Y{*} - G_Y |$ 120

L_Y を読出し 122

Tr, Y_o, a, b を読み出し 124

$$r{*} = \frac{(Tr \cdot S + 1) \cdot Y_o}{a \cdot S^2 + b \cdot S + 1} \cdot \theta$$ 126

$Z = | r{*} - r |$ 128


β
VFR
V1234
VFL
CF
CC
γ
L
O
VRR
VRL
t